CLAIMS

1. An apparatus for controlling a cutting efficiency of an electromagnetically induced mechanical cutter, comprising:

(a) an electromagnetic energy source for focusing electromagnetic energy into a volume of air adjacent to a target surface;

(b) a user input device for specifying one of a high resolution cut and a low resolution cut, and for specifying one of a deep-penetration cut and a shallow-penetration cut; and

(c) an atomizer responsive to the user input device for generating a combination of atomized fluid particles, and for placing the user-specified combination of atomized fluid particles into the volume of air adjacent to the target surface, the atomizer generating:

(1) a combination of atomized fluid particles comprising relatively small fluid particles, in response to a user input specifying a high resolution cut;

(2) a combination of atomized fluid particles comprising relatively large fluid particles, in response to a user input specifying a low resolution cut;

(3) a combination of atomized fluid particles comprising a relatively low-density distribution of fluid particles, in response to a user input specifying a deep-penetration cut; and

(4) a combination of atomized fluid particles which comprises a relatively high-density distribution of fluid particles, in response to a user input specifying a shallow-penetration cut,

wherein the focused electromagnetic energy from the electromagnetic energy source has a wavelength which is

substantially absorbed by the atomized fluid particles in the volume of air adjacent to the target surface, and

wherein the absorption of the focused electromagnetic energy by the atomized fluid particles causes the atomized fluid particles to explode and impart mechanical cutting forces onto the target surface.

2. The apparatus for controlling a cutting efficiency of an electromagnetically induced mechanical cutter according to Claim 1, wherein the user input device comprises a single input for controlling the cutting efficiency.

3. The apparatus for controlling a cutting efficiency of an electromagnetically induced mechanical cutter according to Claim 2, wherein the user input device generates a relatively low-density distribution of relatively small fluid particles when the single input specifies a high cutting efficiency.

4. The apparatus for controlling a cutting efficiency of an electromagnetically induced mechanical cutter according to Claim 3, wherein the user input device generates a relatively high-density distribution of relatively large fluid particles when the single input specifies a low cutting efficiency.

5. The apparatus for controlling a cutting efficiency of an electromagnetically induced mechanical cutter according to Claim 4, wherein each of the

relatively small fluid particles has a fluid-particle diameter, and

wherein a mean fluid-particle diameter of the fluid-particle diameters of the relatively small fluid particles is less than the wavelength of the electromagnetic energy focused into the volume of air adjacent to the target surface.

6. The apparatus for controlling a cutting efficiency of an electromagnetically induced mechanical cutter according to Claim 4, wherein each of the relatively large fluid particles has a fluid-particle diameter, and

wherein a mean fluid-particle diameter of the fluid-particle diameters of the relatively large fluid particles is greater than the wavelength of the electromagnetic energy focused into the volume of air adjacent to the target surface.

7. The apparatus for controlling a cutting efficiency of an electromagnetically induced mechanical cutter according to Claim 1, wherein the target surface comprises cartilage.

8. The apparatus for controlling a cutting efficiency of an electromagnetically induced mechanical cutter according to Claim 1, wherein the target surface comprises a bone.

9. The apparatus for controlling a cutting efficiency of an electromagnetically induced mechanical

cutter according to Claim 8, wherein the target surface comprises a tooth.

10. The apparatus for controlling a cutting efficiency of an electromagnetically induced mechanical cutter according to Claim 1, wherein the target surface comprises glass.

11. The apparatus for controlling a cutting efficiency of an electromagnetically induced mechanical cutter according to Claim 1, wherein the target surface comprises a semiconductor chip surface.

12. An electromagnetically induced mechanical cutter for removing portions of a target surface, comprising:

a user input device for inputting a user-selected combination of atomized fluid particles, the user-selected combination of atomized fluid particles corresponding to a user-selected average size, spatial distribution, and velocity of atomized fluid particles;

an atomizer, responsive to the user input device, for generating the user-specified combination of atomized fluid particles, and for placing the user-specified combination of atomized fluid particles into an interaction zone, the interaction zone being defined as a volume above the target surface; and

an electromagnetic energy source for focusing electromagnetic energy into the interaction zone, the electromagnetic energy having a wavelength which is substantially absorbed by a portion of atomized fluid particles of the user-specified combination of atomized fluid particles in the interaction zone, the absorption

of the electromagnetic energy by the portion of atomized fluid particles causing the portion of atomized fluid particles to explode and impart mechanical cutting forces onto the target surface.

13. The electromagnetically induced mechanical cutter for removing portions of a target surface according to Claim 12, wherein the fluid comprises water, and

wherein the electromagnetic energy source is an erbium, chromium, yttrium, scandium, gallium garnet (Er, Cr:YSGG) solid state laser, which generates light having a wavelength in a range of 2.70 to 2.80 microns.

14. The electromagnetically induced mechanical cutter for removing portions of a target surface according to Claim 12, wherein the fluid comprises water, and

wherein the electromagnetic energy source comprises one of the following:

(a) erbium, yttrium, scandium, gallium garnet (Er:YSGG) solid state laser, which generates electromagnetic energy having a wavelength in a range of 2.70 to 2.80 microns;

(b) erbium, yttrium, aluminum garnet (Er:YAG) solid state laser, which generates electromagnetic energy having a wavelength of 2.94 microns;

(c) chromium, thulium, erbium, yttrium, aluminum garnet (CTE:YAG) solid state laser, which generates electromagnetic energy having a wavelength of 2.69 microns;

(d) erbium, yttrium orthoaluminate (Er:YALO3) solid state laser, which generates

electromagnetic energy having a wavelength in a range of 2.71 to 2.86 microns;

(e) holmium, yttrium, aluminum garnet (Ho:YAG) solid state laser, which generates electromagnetic energy having a wavelength of 2.10 microns;

(f) quadrupled neodymium, yttrium, aluminum garnet (quadrupled Nd:YAG) solid state laser, which generates electromagnetic energy having a wavelength of 266 nanometers;

(g) argon fluoride (ArF) excimer laser, which generates electromagnetic energy having a wavelength of 193 nanometers;

(h) xenon chloride (XeCl) excimer laser, which generates electromagnetic energy having a wavelength of 308 nanometers;

(i) krypton fluoride (KrF) excimer laser, which generates electromagnetic energy having a wavelength of 248 nanometers; and

(j) carbon dioxide (CO2), which generates electromagnetic energy having a wavelength in a range of 9.0 to 10.6 microns.

15. The electromagnetically induced mechanical cutter for removing portions of a target surface according to Claim 13, wherein the Er, Cr:YSGG solid state laser has a repetition rate greater than 1 Hz, a pulse duration range between 1 picosecond and 1000 microseconds, and an energy greater than 1 milliJoule per pulse.

16. The electromagnetically induced mechanical cutter for removing portions of a target surface according to Claim 13, wherein the Er, Cr:YSGG solid

state laser has a repetition rate of 20 Hz, a pulse duration of 140 microseconds, and an energy between 1 and 300 milliJoules per pulse.

17. An apparatus for imparting mechanical forces onto a target surface, comprising:

an atomizer for placing atomized fluid particles into an interaction zone, the interaction zone being defined as a volume above the target surface; and

an electromagnetic energy source for focusing electromagnetic energy into the interaction zone, the electromagnetic energy having a wavelength which is substantially absorbed by the atomized fluid particles in the interaction zone, the absorption of the electromagnetic energy by the atomized fluid particles causing the atomized fluid particles to explode and impart the mechanical forces onto the target surface.

18. The apparatus for imparting mechanical forces onto a target surface according to claim 17, wherein the energy is delivered through a fiberoptic, and

wherein the atomized fluid particles contact the fiberoptic to thereby cool and clean the fiberoptic.

19. The apparatus for imparting mechanical forces onto a target surface according to Claim 18, wherein the atomized fluid particles contact the fiberoptic to thereby remove particulate debris from the fiberoptic.

20. The apparatus for imparting mechanical forces onto a target surface according to claim 18, wherein the fiberoptic comprises sapphire.

21. The apparatus for imparting mechanical forces onto a target surface according to Claim 17, wherein the electromagnetic energy source is an erbium, chromium, yttrium scandium gallium garnet (Er, Cr:YSGG) solid state laser, which generates electromagnetic energy having a wavelength of approximately 2.78 microns.

22. The apparatus for imparting mechanical forces onto a target surface according to Claim 17 wherein the fluid particles comprise water, and

wherein the electromagnetic energy source is an erbium, chromium, yttrium, scandium, gallium garnet (Er, Cr:YSGG) solid state laser, which generates electromagnetic energy having a wavelength in a range of 2.70 to 2.80 microns.

23. The apparatus for imparting mechanical forces onto a target surface according to Claim 22, wherein the Er, Cr:YSGG solid state laser has a repetition rate greater than 1 Hz, a pulse duration range between 1 picosecond and 1000 microseconds, and an energy greater than 10 milliJoules per pulse.

24. The apparatus for imparting mechanical forces onto a target surface according to Claim 17, wherein the fluid comprises water, and

wherein the electromagnetic energy source comprises one of the following:

(a) erbium, yttrium, scandium, gallium garnet (Er:YSGG) solid state laser, which generates

electromagnetic energy having a wavelength in a range of 2.70 to 2.80 microns;

(b) erbium, yttrium, aluminum garnet (Er:YAG) solid state laser, which generates electromagnetic energy having a wavelength of 2.94 microns;

(c) chromium, thulium, erbium, yttrium, aluminum garnet (CTE:YAG) solid state laser, which generates electromagnetic energy having a wavelength of 2.69 microns;

(d) erbium, yttrium orthoaluminate (Er:YALO3) solid state laser, which generates electromagnetic energy having a wavelength in a range of 2.71 to 2.86 microns;

(e) holmium, yttrium, aluminum garnet (Ho:YAG) solid state laser, which generates electromagnetic energy having a wavelength of 2.10 microns;

(f) quadrupled neodymium, yttrium, aluminum garnet (quadrupled Nd:YAG) solid state laser, which generates electromagnetic energy having a wavelength of 266 nanometers;

(g) argon fluoride (ArF) excimer laser, which generates electromagnetic energy having a wavelength of 193 nanometers;

(h) xenon chloride (XeCl) excimer laser, which generates electromagnetic energy having a wavelength of 308 nanometers;

(i) krypton fluoride (KrF) excimer laser, which generates electromagnetic energy having a wavelength of 248 nanometers; and

(j) carbon dioxide (CO2), which generates electromagnetic energy having a wavelength in a range of 9.0 to 10.6 microns.

25. The apparatus for imparting mechanical forces onto a target surface according to Claim 17, wherein the target surface comprises a hard tissue.

26. The apparatus for imparting mechanical forces onto a target surface according to Claim 25, wherein the hard tissue comprises one of tooth enamel, tooth dentin, tooth cementum, bone, and cartilage.

27. The apparatus for imparting mechanical forces onto a target surface according to Claim 17, wherein the target surface comprises a soft tissue.

28. The apparatus for imparting mechanical forces onto a target surface according to Claim 22, wherein the soft tissue comprises one of skin, mucosa, gingiva, muscle, heart, liver, kidney, brain, eye, and vessels.

29. The apparatus for imparting mechanical forces onto a target surface according to Claim 17, wherein the target surface comprises glass.

30. The apparatus for imparting mechanical forces onto a target surface according to Claim 17, wherein the target surface comprises a semiconductor chip surface.

31. The apparatus for imparting mechanical forces onto a target surface according to Claim 17, further comprising an input device for accepting a user input.

32. The apparatus for imparting mechanical forces onto a target surface according to Claim 31, wherein the user input specifies a cutting efficiency of the apparatus.

33. The apparatus for imparting mechanical forces onto a target surface according to Claim 32, wherein at least one physical characteristic of the atomized fluid particles is controlled by the user input.

34. The apparatus for imparting mechanical forces onto a target surface according to Claim 33, wherein the at least one physical characteristic of the atomized fluid particles includes at least one of an average fluid particle size, spatial distribution, and velocity.

35. An apparatus for controlling a cutting efficiency of an electromagnetically induced mechanical cutter, comprising:

an electromagnetic energy source for focusing electromagnetic energy into a volume adjacent to a target surface;

a specification input for specifying at least one of a cutting resolution and a penetration level for the cutting efficiency;

means for selecting one of a plurality of fluid spray nozzles, in response to a user specification of the cutting resolution;

means for selecting an upstream fluid pressure for the selected fluid spray nozzle, in response to a user specification of the penetration level; and

an atomizer for applying the upstream fluid pressure to the fluid spray nozzle, to thereby generate a user-specified combination of atomized fluid particles, the atomizer placing the user-specified combination of atomized fluid particles into the volume adjacent to the target surface, the focused electromagnetic energy being substantially absorbed by the user-specified combination of atomized fluid particles, the user-specified combination of atomized

fluid particles, upon absorbing the electromagnetic energy, exploding and imparting mechanical cutting forces onto the target surface.

36. The apparatus for controlling a cutting efficiency of an electromagnetically induced mechanical cutter according to Claim 35, wherein the specification input comprises:

a first user input for specifying a level of resolution for the cutting efficiency, the level of resolution including one of a high resolution cut and a low resolution cut; and

a second user input for specifying a level of penetration for the cutting efficiency, the level of penetration including one of a deep-penetration cut and a shallow-penetration cut.

37. The apparatus for controlling a cutting efficiency of an electromagnetically induced mechanical cutter according to Claim 36, wherein the atomizer generates a combination of atomized fluid particles comprising relatively small fluid particles, in response to the first user input specifying a high resolution cut,

wherein the atomizer generates a combination of atomized fluid particles comprising relatively large fluid particles, in response to the first user input specifying a low resolution cut,

wherein the atomizer generates a combination of atomized fluid particles which comprises a relatively low-density distribution of fluid particles, in response to the second user input specifying a deep-penetration cut, and

wherein the atomizer generates a combination of atomized fluid particles which comprises a relatively high-density distribution of fluid particles, in response to the second user input specifying a shallow-penetration cut.

38. A method of controlling a cutting efficiency of an electromagnetically induced mechanical cutter, comprising the following steps:

focusing electromagnetic energy into a volume adjacent to a target surface;

specifying at least one of a cutting resolution and a penetration level for the cutting efficiency;

selecting one of a plurality of fluid spray nozzles, in response to a specification of the cutting resolution;

selecting an upstream fluid pressure for the selected fluid spray nozzle, in response to a specification of the penetration level;

applying the upstream fluid pressure to the fluid spray nozzle, to thereby generate a user-specified combination of atomized fluid particles; and

placing the user-specified combination of atomized fluid particles into the volume adjacent to the target surface, the focused electromagnetic energy being substantially absorbed by the user-specified combination of atomized fluid particles, the user-specified combination of atomized fluid particles, upon absorbing the electromagnetic energy, exploding and imparting mechanical cutting forces onto the target surface.

39. The method of controlling a cutting efficiency of an electromagnetically induced mechanical cutter according to Claim 38, the step of specifying at least

one of a cutting resolution and a penetration level for the cutting efficiency further comprising the following steps:

specifying, via a user input, one of a high resolution cut and a low resolution cut; and

specifying, via a user input, one of a deep-penetration cut and a shallow-penetration cut.

40. The method of controlling a cutting efficiency of an electromagnetically induced mechanical cutter according to Claim 39, wherein the step of applying the upstream fluid pressure to the fluid spray nozzle comprises the following substeps:

generating a combination of atomized fluid particles comprising relatively small fluid particles, in response to a user input specifying a high resolution cut;

generating a combination of atomized fluid particles comprising relatively large fluid particles, in response to a user input specifying a low resolution cut;

generating a combination of atomized fluid particles which comprises a relatively low-density distribution of fluid particles, in response to a user input specifying a deep-penetration cut; and

generating a combination of atomized fluid particles which comprises a relatively high-density distribution of fluid particles, in response to a user input specifying a shallow-penetration cut.

41. The apparatus for controlling a cutting efficiency of an electromagnetically induced mechanical cutter according to Claim 40, wherein the step of

applying the upstream fluid pressure to the fluid spray nozzle further comprises the following substeps:

generating atomized fluid particles with relatively high kinetic energies, in response to at least one of a user specification for a deep-penetration cut and a user specification for high resolution cut; and

generating atomized fluid particles with relatively low kinetic energies, in response to at least one of a user specification for a shallow-penetration cut and a user specification for low resolution cut.

42. A method of providing electromagnetically induced mechanical cutting forces onto a target surface to thereby remove portions of the target surface, comprising the following steps:

inputting a user-specified combination of atomized fluid particles, the user-specified combination of atomized fluid particles corresponding to a user-specified average size, spatial distribution, and velocity of atomized fluid particles;

generating the user-specified combination of atomized fluid particles, in response to the user input device;

placing the user-specified combination of atomized fluid particles into an interaction zone, the interaction zone being defined as a volume above the target surface; and

focusing electromagnetic energy into the interaction zone, the electromagnetic energy having a wavelength which is substantially absorbed by a portion of atomized fluid particles of the user-specified combination of atomized fluid particles in the interaction zone, the absorption of the electromagnetic energy by the portion of atomized fluid particles causing the portion of atomized fluid particles to

explode and impart mechanical cutting forces onto the target surface.

43. A method of mechanically removing portions of a target surface, comprising the following steps:

placing atomized fluid particles into an interaction zone above the target surface;

focusing electromagnetic energy onto the atomized fluid particles in the interaction zone; and

exploding the atomized fluid particles in the interaction zone, the explosions of the atomized fluid particles imparting mechanical forces onto the target surface to thereby remove the portions of the target surface.

44. The method of mechanically removing portions of a target surface according to Claim 43, wherein the step of placing atomized fluid particles into the interaction zone above the target surface includes a substep of placing atomized water particles into the interaction zone above the target surface.

45. The method of mechanically removing portions of a target surface according to Claim 44, wherein the step of focusing electromagnetic energy onto the atomized fluid particles in the interaction zone comprises a substep of focusing electromagnetic energy from an erbium, chromium, yttrium scandium gallium garnet (Er, Cr:YSGG) solid state laser, which generates electromagnetic energy having a wavelength of approximately 2.78 microns, onto the atomized water particles in the interaction zone.

46. The method of mechanically removing portions of a target surface according to Claim 43, wherein the target surface comprises a tooth.

47. A method of imparting mechanical forces onto a target surface, comprising the following steps:

generating a fluid particle;

placing the fluid particle into an interaction zone, the interaction zone defining a volume of space adjacent to the target surface;

introducing electromagnetic energy into the interaction zone;

exploding the fluid particle to impart the mechanical forces onto the target surface.

48. The method of imparting mechanical forces onto a target surface according to Claim 47, wherein the electromagnetic energy has a wavelength which is substantially absorbed by the fluid particle, and

wherein a curvature of an outer surface of the fluid particle focuses the electromagnetic energy into an inner portion of the fluid particle to thereby cause an expansion of fluid in the inner portion of the fluid particle.

49. An optical cutter for dental use, comprising:

a housing having a lower portion, an upper portion, and an interfacing portion;

a first fiber optic tube for carrying laser energy through the housing to the upper portion of the housing;

a first abutting member fitting around the first fiber optic tube at the upper portion of the housing;

a second fiber optic tube having a proximal end and a distal end;

a second abutting member surrounding the second fiber optic tube at the proximal end and contacting the interfacing portion of the housing; and

a focusing optic positioned between the first abutting member and the second abutting member, the focusing optic focusing laser energy as the laser energy passes from the first fiber optic to the second fiber optic to thereby reduce dissipation of laser energy between the fist fiber optic and the second fiber optic.

50. The optical cutter for dental use according to Claim 49, further comprising a cap having an input portion and an output portion, the cap fitting over the interfacing portion of the housing.

51. The optical cutter for dental use according to Claim 49, wherein the distal end of the second fiberoptic tube comprises sapphire.

52. The optical cutter for dental use according to Claim 49, wherein the first fiberoptic tube comprises a trunk fiberoptic, which comprises one of calcium fluoride (CaF), calcium oxide (CaO2), zirconium oxide (ZrO2), zirconium fluoride (ZrF), sapphire, hollow waveguide, liquid core, TeX glass, quartz silica, germanium sulfide, arsenic sulfide, and germanium oxide (GeO2).